

**Response of sweet fennel plant
(*Foeniculum vulgare* Mill) to field practices and their effects
on growth characters crop yield and the active constituents of
the fruits**

**استجابة نبات الحبة الحلوة
(*Foeniculum vulgare* Mill)
للمعاملات الحلقية واثرها في صفات النمو والحاصل والمكونات الفعالة**

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Abstract

Two field experiments were carried out during winter season of the seasons 2004-2005 and 2005-2006 at the field of the College of Agriculture; (University of Baghdad at Abu-Graib district. Baghdad, Iraq.

The experiments designed to investigate the effect of field spaces and the fertilization of crops and, their effects on the growth, yield, quantity and quality of the seed harvest of fennel and their content of volatile oil and its specification.

The spaces used were of 10, 20 and 30cm between each plant; two types - of fertilizer were used, the urea with its nitrogen content of 46% and the phosphorous fertilizer with its super phosphate of 48-52% P2O5. The quantities of fertilizer used were of 30, 60 and 90 kg/hectare.

The results indicate the increasing space between the fennel plants with increasing of fertilizers application caused a significant increase in the parameter value in the two seasons.

Plants grown at 30cm a part, combined with 180 kg and 90 kg of urea and phosphorus fertilizers gave the greatest value of vegetative growth, flowering growth, fruit, and seed volatile oil yield contents as quantity and quality in relation to their physical properties

The volatile oil content of anethole is increased with the increasing of the nitrogen fertilizer, while the percentage of fenchone was correlated with increasing of phosphorous fertilizer.

The highest percentage of anethole 76.97% was obtained at the metrication treatment of the 30cm space and 180kg and 30kg hectare of nitrogen and phosphorus fertilizer while the highest percentage of fenchone was obtained at interaction treatment of 30cm space and 90kg, and 120 kg of nitrogen and phosphorus fertilizer respectively.

الخلاصة :-

نفذت تجربتان حقليتان خلال الموسمين الشتويين 2004-2005، و2005-2006 في حقل تجارب كلية الزراعة - جامعة بغداد- ابو غريب لتحديد استجابة نبات الحبة الحلوة لمسافات الزراعة ومستويات التسميد النتروجيني والفوسفاتي واثر ذلك في صفات النمو وحاصل الثمار والزيت الطيار، حيث استخدمت مسافات زراعة 10، 20، 30سم بين النباتات كمعاملات رئيسية وعشرة توليفات سمادية كمعاملات ثانوية بواقع ثلاث مستويات من السماد النتروجيني 60، 120، و180 كغم/ هكتار على هيئة يوريا (46% N) وثلاث مستويات من السماء الفوسفاتي 30، 60، 90 كغم/ هكتار على هيئة سوبر فوسفات ثلاثي (48-52% P₂O₅) بالإضافة الى معاملة المقارنة بدون تسميد. اظهرت النتائج ان زيادة مسافات الزراعة بين النباتات مع زيادة مستويات التسميد اثر معنويا في عدد الافرع وعدد النورات الزهرية وحاصل ثمار والزيت الطيار. حيث اعطت المسافة 30 سم بين النباتات مع مستويات 180كغم و90كغم/ هكتار سماد نتروجيني وفوسفاتي على التوالي اعلى القيم للصفات المدروسة.

لقد اشارت النتائج ان زيادة نسبة مادة الانيثول anethole في الزيت الطيار ترافقت مع زيادة مستويات التسميد النتروجيني في حين ترافقت زيادة نسبة مادة الفنكون Fenchone مع زيادة مستويات التسميد الفوسفاتي، وكانت اعلى نسبة لمادة الانيثول عند المسافة 30سم بين النباتات ومستويات تسميد 180كغم/هكتار سماد نتروجيني و30 كغم سماد فوسفاتي وبلغت 76.97% في حين بلغت نسبة مادة الفنكون 16.657% عند المسافة 30سم بين النباتات وعند مستويات تسميد 120كغم/هكتار سماد نتروجيني و90كغم/هكتار سماد فوسفاتي.

Introduction

The cultivation of several medicinal and aromatic species in Iraq had noticeably increased in recent years. However, the use of the most suitable and recommended agricultural practices in growing such crops could provide the farmers with higher income, in comparison with many other traditional crops. *Foeniculum vulgare* Mill. (Family: Umbelliferae) is one of the most promising crops of the species cultivated in Iraq, because of its widely used in folklore medicine and its uses in different pharmaceutical preparation.

The ripe fruits of fennel accommodate an important essential oil, which contains the active constituents of anethole and fenchone and some others. Such compounds are used as diuretic, carminatives, sedative (1), galactagogic, emmenagogic, expectorant and antispasmodic (2). It is also used as emolient, and to control some diseases affecting chest, lungs, spleen, kidneys and in colic pains(3).

Nitrogen and phosphorus are considered as essential elements for the growth and the biosynthesis of the active constituent of the plant (4).

The effect of spacing between fennel plant have main effect on the role of competition among plants on growth factors such as water, light and nutrients (5). The essential oil of fennel which contain anethole (-p- propylanisole) and Fenchone as dicyclic ketone are considered very important in pharmaceutical and others industrial as well as using in confectionery(6).

So the objective of this study is to evaluate the effect of the planting spaces and the fertilizer of nitrogen and phosphorus on the growth of the fennel plant as well as the content's of essential oil and its active constituents from physical -and chemical stand view in comparison with the standard products.

Materials and Methods

Two field experiments were conducted during the two successive winter seasons of the year 2005 and 2006 at the fields of the college of Agriculture, university of Baghdad, Abu - Graib, Iraq.

Fennel seeds were obtained from the center of Herbal Medicine of the Health Ministry of Iraq, and were sown on 10th of November of each season in hill after authentication from the National Herbarium center of the agricultural Ministry in Abu - Graib and confirmed by prof. Dr. AL- Musawy college of science, Baghdad University, Iraq.

The design of experiment follows the split-plot design in Randomized Complete Block Design (RCBD), with three replications included 30 plots, the area of each plot was nine square meter (9m²) contained four rows; with seventy five centimeter (75cm) between rows and three meter between each replicate; the planting spaces between each plant were ten, twenty and thirty centimeters spaces.

The treatments with fertilizers were the combination of three level treatment; sixty, one hundred twenty and one hundred eighty (60, 120 and 180) Kg/ hectare with nitrogen fertilizer as urea of 46% nitrogen.

Other treatments were done with Phosphorus fertilizer (48-52% P₂O₅), at three levels; thirty, sixty and ninety (30, 60, 90) Kg/ hectare as subplot treatments.

Phosphorus fertilizer was added before planting while nitrogen fertilizer was added in two equal quantities at two times. The first application at 10 days after thinning and the second at 75% of flowering stage.

The samples for study were randomly chosen from the middle rows of each plot. The data recorded were subjected to analysis of variance and least significant difference (L.S.D), at 0.05 levels compare the means of characters.

Chemical analysis:

The volatile oil of fennel fruits was obtained by processes of steam distillation(7). The study

of the effect different fertilization and spaces treatments on the main constituents of the essential oil representative samples of the extracted oil from each treatment were analyzed in a semi quantitative method using GLC.

The extracted oil has been diluted with n- hexane, injected into GLC using an auto- sampler and the different compounds have been separated on a HP - INNOWOAX (60 x 0.25 x 0.25 μm) capillary column. Helium was used as carrier gas (flow rate 1.5 ml min⁻¹). The temperature program was 35°C to 230°C (2.5°C per min) in course of time (92 mm), injector temperature was 205°C and flame ionization detector used, area percentage, were obtained using a PC programmer (Maestro chromatograph data system). For identification of single compound internal and external standard substances have been used, the external standard was obtained from Oma company for chemical compounds.

Instrument:

The main instruments were used during this study included:

- The Refractometer (B5) from kallingham limited CO.
- Gas liquid chromatogram phy (GLC) with AR-ss Linear recorder from shimadzo Co.
- Clevenger for steam distillation of volatile oil extraction.

Statistical analysis:

The collected data of the growth parameties were subjected to statistical analysis using the SAS programmer (1985), ,data obtained (means of the two growing seasons) were subjected to analysis variance procedure. The values of LSD (Least significant difference) were obtained whenever F values at 5% level (8).

Results and discussion

To evaluate the parameters discussed; growth properties, fruit yield and its essential oil content and components of the volatile oil should be consdered.

The space between plants showed significant effects on the all parameters; planting space of 30 cm caused a great increase in plant number of branches, number of main inflorescences and fruit yield, while other spaces produced lower values (Table 1).

The significant increase of growth and yield by increasing the planting space was due to the reduction of competing effect between plants to the water, sunlight and minerals (9).

Beside that, the fennel plant was responded significantly to the applied nitrogen and phosphorous fertilizers especially to the quantity of 180 and 90 Kgm/ hectare respectively.

The increasing of percentage yield of volatile oil by increasing nitrogen and phosphorous fertilizer was due to the effect on the synthesis of triacyl- glycerol from glycerol- 3 phosphate (10), which lead to Mavelonic acid and to isoprene unit which is the building block of ten terpenoid volatile oil, at the same time the aromatic ring. also needs the phosphorus fertilizer as building block of the two important molecule phosphoenolpyruvic acid erythrose-4- phosphate. Their combination produced shikimic acid and chorismic acid to pheyproenoid derivatives(11), (12), (13), (14).

The quality volatile oil also increased by increasing space of planting and the application of phosphorus and nitrogn fertilizer.

The values of specific gravity, oil density and refractive, which reached 0.979; 0.962 mg/ μl and 1.548 degree respectively. This increase may be due to increasing the accumulation of oxygen compounds (as solid compounds) in fennel volatile oil.

(Table2) showed the compression values of the standard volatile oil properties as mentioned in United States Pharmacopoeia (USP) and the produced oil of the fennel plant of the experiment(15).

The volatile oil obtained from fennel seeds was analyzed using gas liquid chromatography showed the volatile oil consist ten compounds which differ in their percentage: Anethole, Fenchone, a-pinene, camphene, octanole, menthone, limonene, citronelellol, estragole and geraniole.

The planting space of 30 cm give more percentage of anethole and. fenchone in comparison of the 10 and 20 cm planting spaces.

Table-3-shows the percentage of anethole which was correlated with increasing level of nitrogen fertilizer while fenchone percentage correlated to the level of phosphorous fertilizer. The highest value of anethole was 76.75% at 30 cm space and 180, 30 kg/ hectare, nitrogen and. phosphorus fertilizers while the highest percentage of fenchone 16.65% was obtained at interaction treatment (30 cm. space and 120 and 90 Kg/ hectare) nitrogen and phosphorous fertilizer (Table 4). The percentage of anothole and fenchone was more than that percentage of standard oil content which was in the study.

Table (1)

The effect of planting spaces, nitrogen and phosphorus with their interaction on branches/ plant, number of main inflorescence, fruits yield (kg/ hectare), volatile oil(%) and volatile oil yield (L/hectare)

Spaces (cm)	Treatment		No. of branches per plant	No. main inflorescence per plant	Fruits yield Kg/hectare	Vol. oil percentage	Vol. oil yield L/hectare
	Fertilizers (kg/ hectare)						
	N	P					
10 cm	0	0	2.36	12.58	745.10	0.39	2.90
	180	30	4.34	23.14	1435.24	0.84	11.90
	180	60	4.56	24.31	1493.31	0.86	12.84
	180	90	5.00	26.65	1610.43	0.93	14.89
20 cm	0	0	3.76	19.79	1210.12	0.97	11.74
	180	30	6.51	34.71	2093.43	1.24	25.95
	180	60	6.76	35.93	2170.24	1.26	27.34
	180	90	7.05	37.58	2268.52	1.32	29.94
30 cm	0	0	5.66	30.17	1420.06	1.80	15.76
	180	30	12.06	64.30	3103.28	2.20	68.27
	180	60	13.03	69.47	3261.17	2.25	73.73
	180	90	17.93	79.60	3282.02	2.30	75.49
L.S.D 5%			1.324	4.991	144.645	0.144	3.222

L.S.D.= Least significant differences, by statistical analysis.

N nitrogen fertilizer

P= phosphorus fertilizer.

Table (2)

Comparison of physical properties of fennel volatile oil at A3B9 treatments (30 cm) space between plants with 180 and 90 kg /hectar nitrogen and phosphorus fertilizers with the same properties in USP (United States Pharmacopeia)

Physical properties	USP	A3B9 treatment
Specific gravity	0.953-0.980	0.976-0.979
Density (mg/micro liter)	0.893-0.925	0.959-0.962
Refractive index	1.538-1.428	1.543-1.548

Table (3)

The effect of planting spaces, nitrogen and phosphorus fertilizers with their interaction on concentration on concentration of vol. oil compounds (%) of fennel plant by using (GLC)

Geraniole	Octanole	Camphene	Citronellol	Limonene	Menthone	α -Pinene	Estraglo	Fenchone	Anethole	Fertilizers (kg/ hectare)			Spaces
										P	N		
3.1534	2.3211	2.6627	1.6763	1.8345	12.8532	2.6712	2.3064	9.9157	60.5853	60	180	B8	10cm
4.2180	3.2427	3.3433	3.1351	4.0365	8.5571	3.6281	3.9583	12.1351	52.4401	90	180	B9	
6.6842	7.0886	5.4745	4.9302	5.0477	9.8005	6.7419	4.1666	6.6583	43.4047	0	0	B10	
-	2.3652	2.8414	0.8405	1.901	13.7029	4.1061	1.9504	10.9582	61.3343	60	180	B8	20cm
3.8788	2.3181	2.3919	1.9188	2.3696	15.4948	1.6763	2.5531	15.7832	51.6154	90	180	B9	
-	4.8589	6.2771	6.9828	5.4891	9.6436	5.2889	3.0973	10.7140	47.6484	0	0	B10	
-	3.3606	5.3125	4.1815	3.7314	3.7314	4.6657	2.7274	16.6575	55.8022	90	120	B6	30cm
-	1.3367	1.9920	1.7275	1.7275	5.2713	2.5292	3.2098	5.3454	76.7591	30	180	B7	
-	2.5722	2.8480	1.7310	1.9075	10.0369	3.4787	2.6036	11.3415	63.4735	60	180	B8	
-	1.9436	2.5488	3.9429	3.5474	1.9436	-	3.1381	16.4788	67.1062	90	180	B9	
-	4.0717	3.9837	4.0614	4.8361	12.1779	2.4708	3.5447	12.2447	52.6091	0	0	B10	

P- Phosphorous fertilizer

N- Nitrogen fertilizer

Table (4)

Comparisons of vol. oil constituents of fennel at A3B7 (30 cm with 180 and 30 kg/hectare) nitrogen and phosphor fertilizers and A3B6 (30 cm with 120 and 90 kg/hectare) nitrogen and phosphorus fertilizer with vol. oil constituents of external standard

Vol. oil compound	External standard	Treatment	
		A3B7	A3B6
a-pinene	2.1613	2.5292	4.6657
Camphene	2.8581	1.992	5.3125
Octanole	2.939	1.3376	3.3606
Menthone	12.4226	5.2713	3.5612
Limonene	4.8323	1.7275	3.7314
Citronellole	4.4882	1.7202	4.1815
Fenchone	12.8524	5.454	16.6575
Estragole	3.4483	3.2089	2.7274
Anethole	45.797	76.7591	55.8022
Gerainole	0.00	0.00	0.00

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